Wireless Current Sensor
User Manual

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Berkshire Products, Inc.
Phone: 770-271-0088
http://www.bkp-store.com/

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1 Introduction

The Wireless Current sensor is designed to measure AD or DC currents up to 5 Amps at a maximum of 32V. It is designed to sense positive or negative AC current levels or high / low DC current levels and use the set points to trigger an XBee wireless module to send a notification.

1.1 XB compatibility

The Wireless Current Sensor can be used with XBee[1] radio modules to allow remote communications and control. Xbees are designed to use very little power except when the radios are transmitting data.

The board can be used with the following types of XBee & XBeePro radios in Series 1 & 2 footprints:

- DigiMesh[2] 2.4G
- DigiMesh[2] 900MHz
- 802.15.4
- 900MHz
- 868MHz
- Zigbee
- WiFi

For best results we recommend that you use XBee radios with the RP-SMA antenna connector or the mini whip antenna. These will experience the least interference from the copper areas on the PCB. The XBee radios with chip and PCB antennas will still work but their range may be reduced.

Note 1: XBee is a registered trademark of Digi International Inc.
Note 2: DigiMesh is a registered trademark of Digi International Inc.

2 Making Connections and Jumper Settings

Refer to following PCB diagram for component placement.

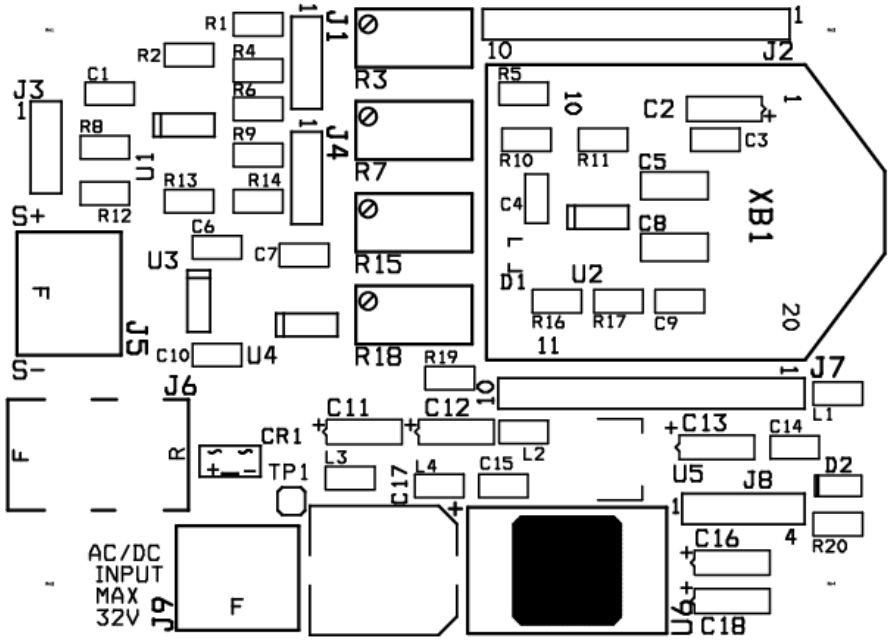


Figure 2-1

2.1 AD/DC Power Input Jumper – J6 or J9

The board can accept DC or AC power input. This can be with stripped wires connected to the screw terminal at **J9** or the 2.1mm power connector **J6** (see Figure 2-1). The DC supply is not polarity sensitive since the board has a bridge rectifier on the input. DC power is the preferred input type if available.

Note: Do not exceed +32V supply input to the board! You can measure the input voltage at **TP1** and GND (Pin 3 or 4 on **J8**).

The power supply must able to source enough current to power the board and the XBee radio in TX mode. This will typically be up to 500mA (0.5A) for the higher powered XBee radios. The input pre-regulator on the board is an 80% switcher supplying +5V volts so your input supply needs to provide about 3.1W. If you have a +12V supply then it should be rated at 250mA minimum.

2.2 AC/DC Current Sensing– J1, J3, & J4

The circuit is designed to sense AC or DC currents. More information will be supplied in the theory of operation section. For now note that these three jumpers should all be in the same position as follows:

Pin 1-2: – Select AC operation
Pin 2-3: – Select DC operation

2.3 Current Sense Terminal – J5

This two position screw terminal is used to sense the current. Notice that the top pin is labeled **S+** and the other is **S-**. These are the required polarity connections when you are using DC sensing. For AC connections it does not matter.

Note: Do not try to measure currents higher that 5 Amps or voltages greater than 32 Volts. The board is not designed for operation above these levels.

2.4 Unstuffed Headers – J2, J2, & J8

These headers are not stuffed on the board and leave you the option of stuffing headers or receptacles on 0.100" centers. **J2** and **J7** are connected one-to-one with the XBee pins and **J8** gives access to +5V, +3.3V, and GND. See the schematic diagram for more information.

3 Theory of Operation and Configuration

Before we start we need to make one thing clear: this is not a precision scientific instrument. It is designed to allow you to measure / sense currents and report the results wirelessly.

3.1 Input Sense Circuit

The heart of input section of the circuit is the current sense IC made by Allegro: Part Number **ACS712.** When the current thru the chip is zero amps the output on pin 7 is a nominal 2.5V. As the current swings plus or minus, the output voltage changes at a rate of 185mV per Amp. Since this is a 5 Amp sensor the output can vary a total of ±925mV (0.925V).

3.2 Conditioning circuit

Two OP-Amps (**U1** & **U7**) make up the AC/DC conditioning circuit. When the jumpers (**J1**, **J3**, & **J4**) are in the AC position, the output of **U1A** is set to be about 1.650V at zero current. Its amplification is set so that full scale plus/minus current (±5A) will range from 0.135V to 3.185V. When the jumpers (**J1**, **J3**, & **J4**) are in the DC position, the output of **U1A** is set to be about 0.050V at zero current and 3.245V at the maximum current of 5A. The output of **U1A** is connected to an analog XBee pin so you can set the XBee for timed sample rate reporting.

OP-Amp **U4B** is used to buffer the output of **U1A** for the comparator section.

3.3 Comparator section

The output of **U4B** drives the two comparators in **U2** through Shottky isolation diodes in **D1**. Comparator **U2A** is set to go high (+3.3V) if the AC current (positive swing) or DC current exceeds a certain level. Trim pot **R15** sets the current level for the trigger point and trim pot **R18** sets the decay time along with **R19** and **C8**.

Comparator **U2B** is set to go high (+3.3V) if the AC current (negative swing) or DC current (low) exceeds a certain level. Trim pot **R7** sets the current level for the trigger and trim pot **R3** sets the decay time along with **R5** and **C5**.

3.4 Circuit Setup

On the XBee radio you need to program the digital inputs **DIO1** and/or **DIO2** to Change Detect mode to report the comparator changes as required. You can disable the low side comparator, **U2B** via XBee programming or by using **R7** to set the voltage at pin 6 of **U2B** to 0.0V.

You should set the decay trim pots **R3** and **R18** such that the decay is not too fast. If it is too fast you will get a pulsing DC signal at the comparator pins which will cause the output to generate multiple triggers to the XBee radio. Note that **R5** and **R19** (10K Ohm) are in the circuit to prevent short circuits if you reduce the trim pots to zero Ohms. In most cases the decay trim pots can most likely be set at their maximum clockwise position. Note that these are 10 turn pots.

C5 & **C8** are 1.0µF - 5% tolerance parts in 1206 packages. They can be increased easily by soldering additional capacitors to them in parallel if you need longer decay times.

3.5 An Example

Let's say you want to trigger when AC current hits 2A. Set your jumpers **J1**, **J3** & **J4** to the AC position (pins 1-2). At this point you know the nominal output of **U4B** will be 1.65 volts and the maximum swing is 3.185V. That gives the following equation:

$$V_{trip} = 1.650V + (2 * ((3.185 – 1.650) / 5)) \quad => \quad +2.265V$$

At that current the voltage at the sense pin 3 of **U2A** will be 2.265V minus the voltage across the diode in **D1** (about 0.15V*) or about 2.115V. In order to provide some margin and make sure that the pulsed DC does not cause multiple triggers; you might start with setting the voltage level at pin 2 of **U2A** to about 2.00 to 2.05V.

* The voltage drop in Shottky diodes is very low at low currents.

4 Configuring the XBee Radio

The examples shown here use an XBee 2.4G DigiMesh version with Digi's X-CTU software which is free and available from Digi International (www.digi.com). To program the radios we use the UARTSBee V4 device which provides power and a USB UART connection to the PC. They are available from Amazon (www.amazon.com) and other sources and look similar to this picture:

Figure 4-1

These devices are also useful for connecting to your PC to use as the "base station" to talk back and forth with the remote I/O module's XBee radio.

Note: Be aware that this board may not be able to supply enough power for an XBee Pro type radio if you plug it into a USB hub.

Note: When the device is first plugged in you may get an alert from your PC that it needs to install drivers for a new device. The UARTSBee uses the FTDI chip for USB to Serial conversion and most PCs have these drivers pre-installed. If yours doesn't, go to www.ftdi-chip.com to get the latest ones for your PC and OS.

4.1 Starting X-CTU

When you start X-CTU you should see a screen like the following:

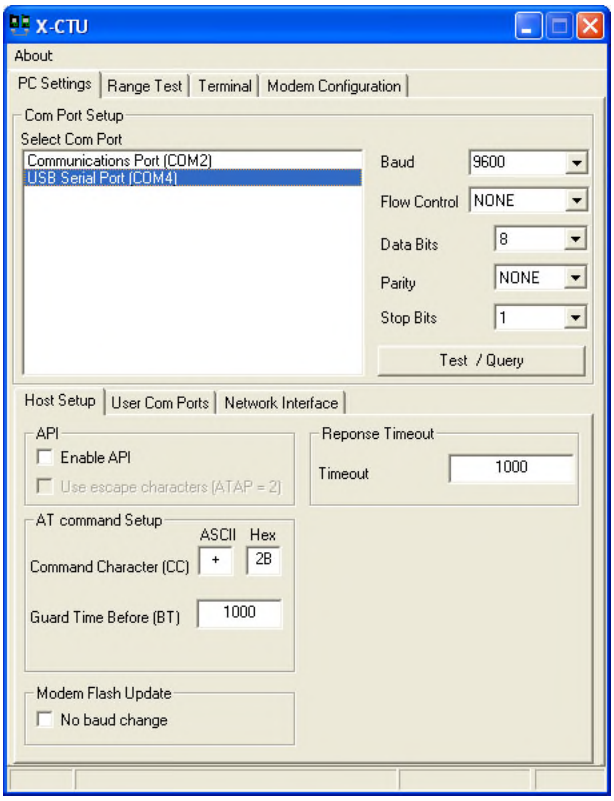


Figure 4-2

In this example the USB → Serial was on COM4. The baud rate should be 9600 to start with, since that is how the XBees are shipped from Digi. Click the Test / Query button to see if the XBee is active. If so, you should get a window like this:

Figure 4-3

Is this case the test was OK. It found an XB24 or a 2.4G DigiMesh. If it had been the higher power Pro it would have been XBP24. The firmware version is shown along with its serial number (IEEE Address) which is HEX: 0013A200 40870B85. The address is always 8 Bytes (64 bits) and leading zeros are not shown. Most Digi XBees start with 0013A200. It is also shown on the label on the bottom of the module.

4.2 Configuring the Networking

The next step is to click the Modem Configuration tab and then press the Read button to get a screen like the following:

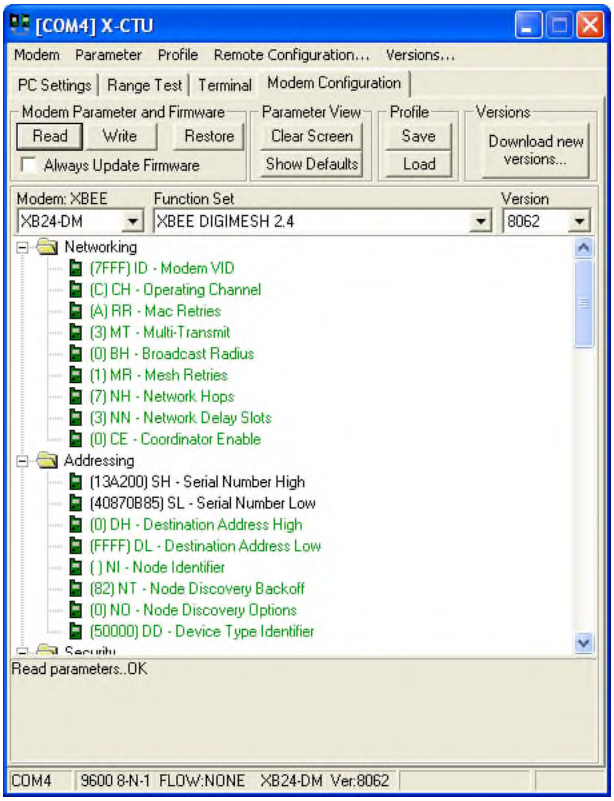


Figure 4-4

Under the Networking section there are options that you can change. Note that different types of modules will have different options. The ones shown here are for DigiMesh. For this module type the only two changes that we will talk about are the VID and the Channel.

- **Modem VID:** This is a HEX number that sets the PAN (Personal Area Network) ID for the network. Valid range is 0-0xFFFF. All the XBees on your network should use the same VID.
- **Operating Channel:** This sets the operating channel number (Uses 802.15.4 channel numbers). Note two things here:

1. XBee modules have more channels available than XBee Pro modules, so be sure to select an operating channel that both types can use if you have mixed modules on your network.
2. Select a channel number that minimizes conflict with any Wi-Fi networks you have. There are docs on the web that show 802.15.4 channel assignments.

See the Digi manual for specifics on other networking options.

4.3 Configuring the Addressing

XBee modules talk to each other using their serial numbers or a 16 bit addressing scheme. We will show the 802.15.4 64 bit scheme here. The Digi XBee manuals show you how to use short addresses.

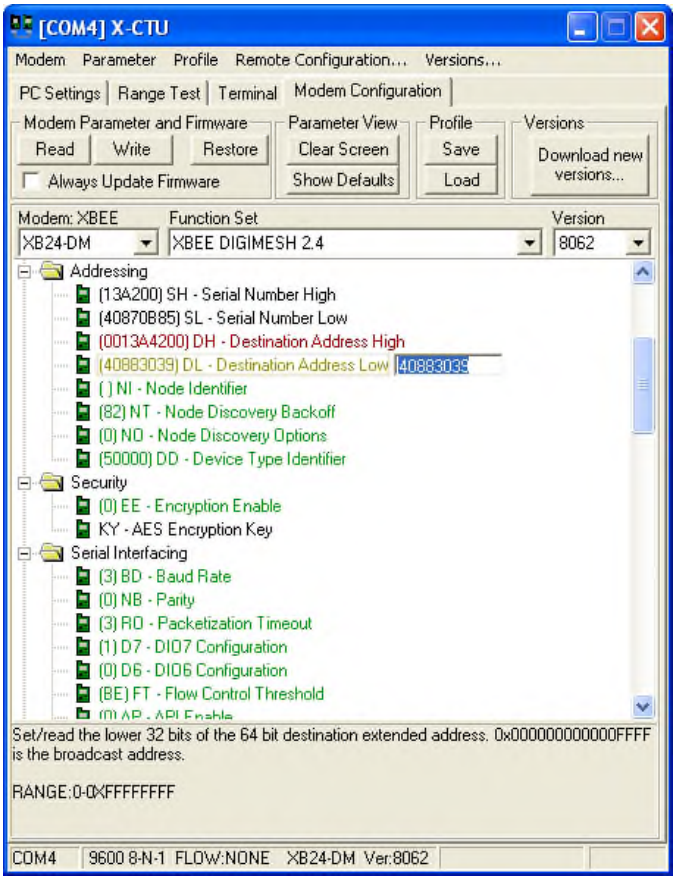


Figure 4-5

In this example we are programming a module for an I/O board that will talk to a host module (base station) at regular intervals. So in this case we set the High order 4 Bytes to the standard XBee address of 0x0013A200 and the lower 4 bytes to the address of our base station module 0x40883039. Once this is set, the module will know what address to send API packets to when an input changes or when a sample must be sent.

4.4 Configuring the Serial Interfacing

There are a few options to set here:

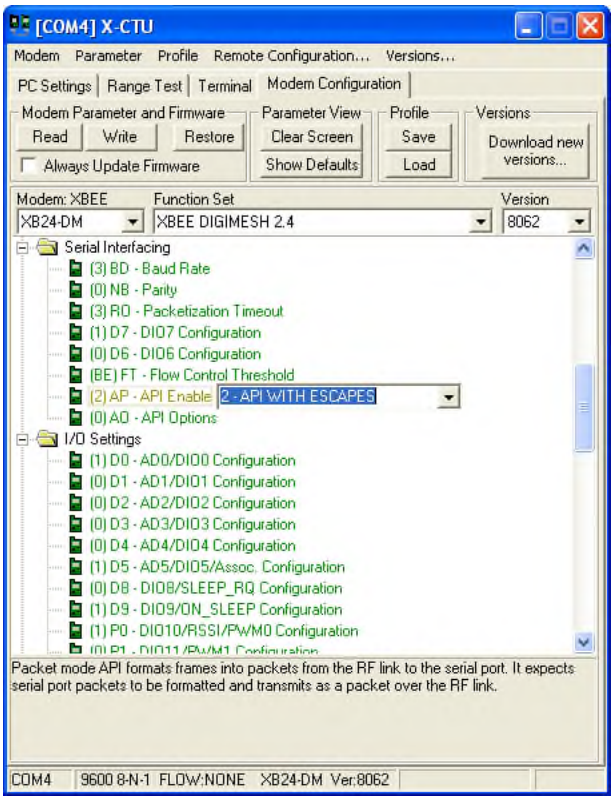


Figure 4-6

One option that needs setting here is the API enable. API mode must be enabled if the XBee module on the I/O board is going to be able to transmit input pin information and set the outputs. API mode 2 is used by the Arduino XBee library if you plan to use an Arduino type board as your base station.

Also note that the Digital I/O pins DIO6 and DIO7 are configured here. The reason for that is they can also be used as serial port flow control pins. If you are using DIO6 and DIO7 on your module then you should configure them here as Inputs or Outputs.

4.5 Configuring I/O Settings

Here is where you configure the I/O pins for DIO0 to DIO5 (see prior section for DIO6 & DIO7):

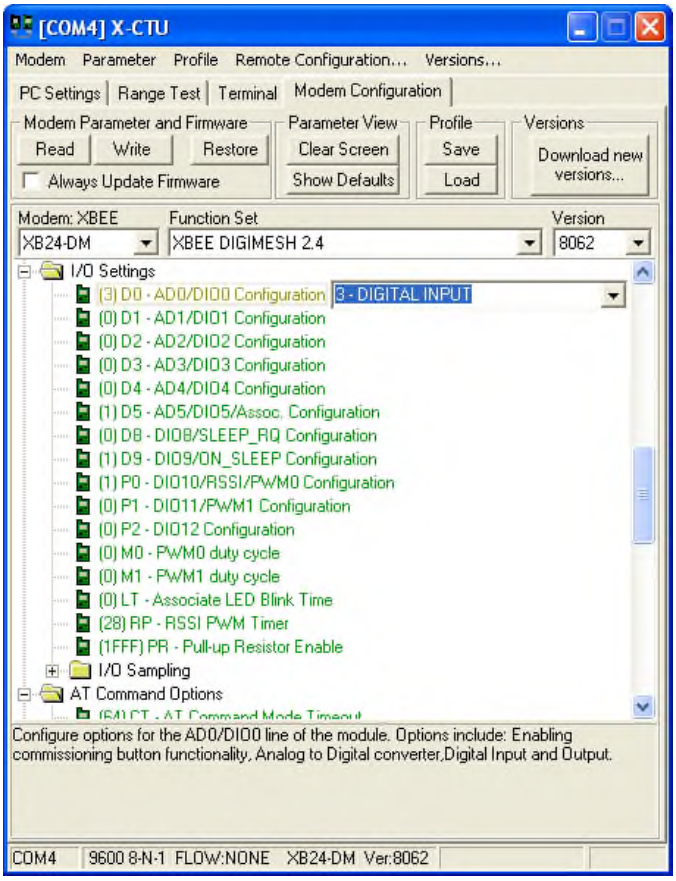


Figure 4-7

Configure DIO0 to DIO5 pins as input or output to match your I/O board setup. DIO8 to DIO12 are not used and should be left as **0-Disabled**.

The PR field defaults to 0x1FFF or binary 1 1111 1111 1111. Each bit set to one (1) defines a pull-up resistor on input pins DIO12 to DIO0. The default values should be fine unless you are using the input pins for analog inputs. In that case the lower six bits should be zero for any pin that is an analog input.

4.6 Configuring I/O Sampling

This is the last area of X-CTU covered here:

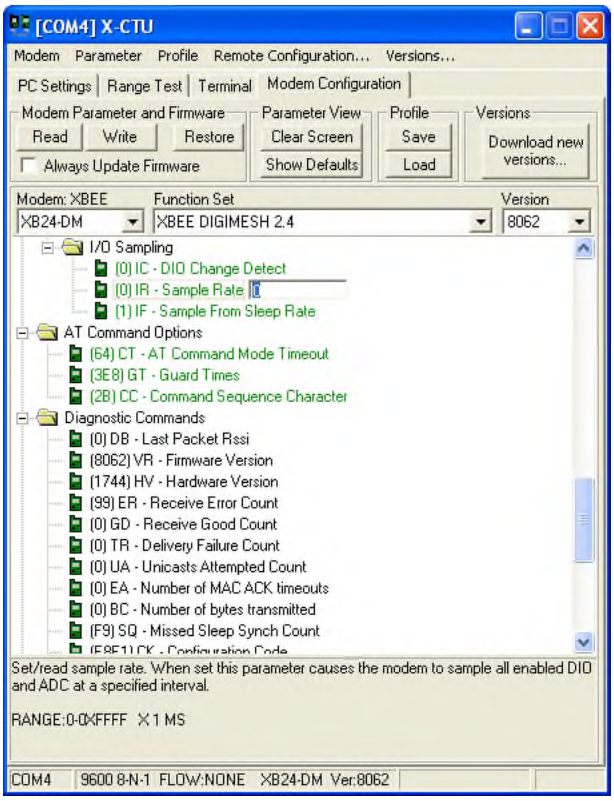
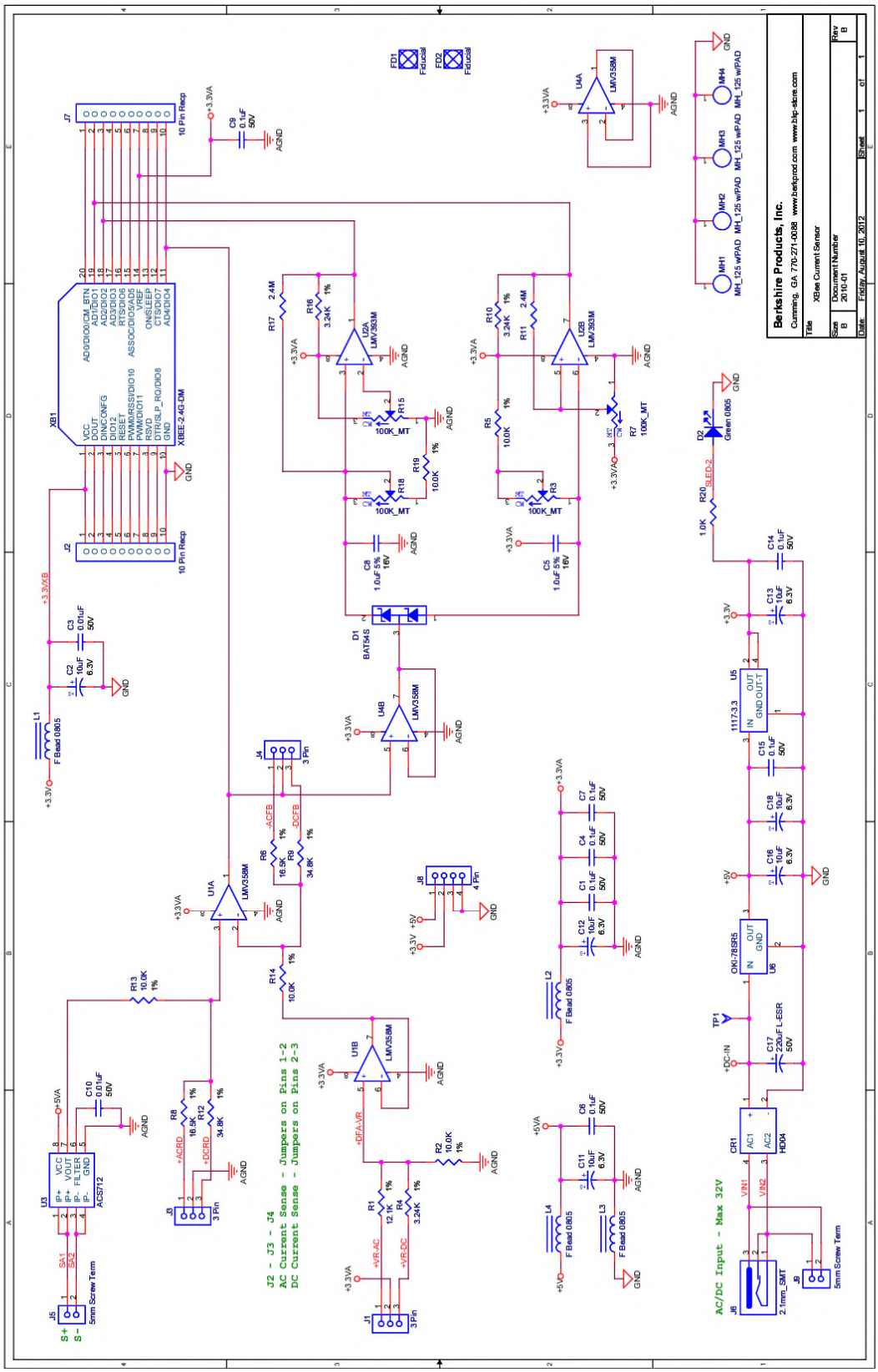


Figure 4-8

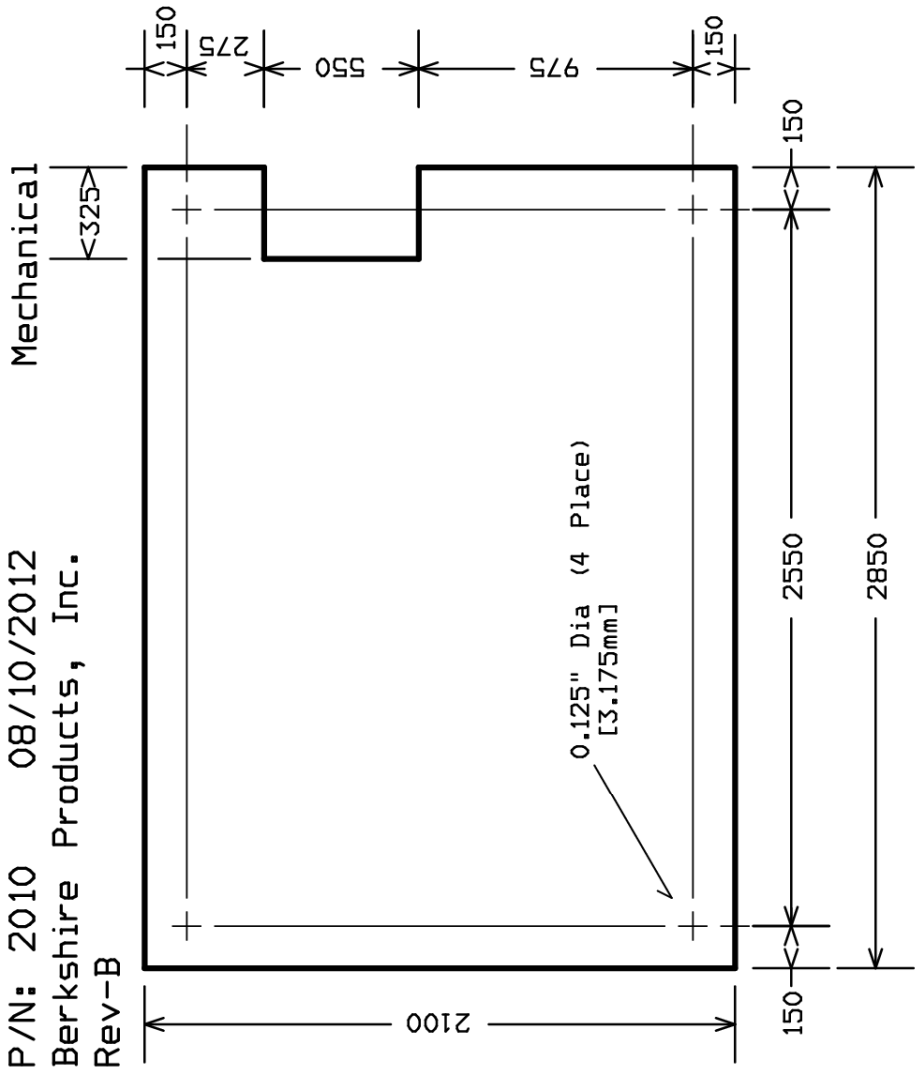
The **DIO Change Detect** is a bit field and should be set to a hex value. Any bit that is set will cause the XBee to send a packet when the I/O line for that bit changes (goes low to high or high to low) and the pin is set as an input. For example if you set this field to 0x2C (binary 0100 1100) then it would send a data packet if DIO6, DIO3 or DIO2 changes state on its input.

The **Sample Rate** tells the XBee module to send a data packet at regular intervals to report the status of digital and analog input pins. The number is in milliseconds so a reasonable minimum value is about 0x80 or 128mS. If an edge change is programmed and it occurs between samples then a packet will be sent then as well. The maximum value for this field is 0xFFFF or 65,353mS. A value of zero stops the samples.

5 Schematic Diagram



6 PCB Mechanical



Note: Dimensions are in mils.

7 Appendix A – Specifications

Power Requirements:

- 8V @ 400mA – minimum
- 32V maximum @ 100mA

Do not exceed +32V input. The Input DC voltage (after the bridge rectifier) can be monitored at TP1 (see Figure 2-1) on the board.

Environmental:

- -30° to +65°C - Operating
- -40° to +85°C - Storage
- 5% to 95% Relative Humidity, non-Condensing

8 Appendix B - Warranty

Berkshire Products, Inc. warrants to the original consumer or other end user purchaser that this product is free from defects in materials or workmanship for a period of one (1) year from the date of purchase. During the warranty period, and upon proof of purchase, the product will be repaired or replaced (with the same or functionally equivalent model) at our option, without charge for either parts or labor.

This warranty does not apply to defects due directly or indirectly to misuse, abuse, negligence, accident, repairs or alterations made by the customer or another party.

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